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13. ABSTRACT (Maximum 200 words)

This work examines the electronic structure of new fullerene compounds by the combination of in situ transport measurements as a function of temperature and photoemission spectroscopy. In particular, we have grown thin films of cerium fullerides, Ce_xC_{60}, $0.5<x<13$, by co-evaporation of multiple molecular beam sources. Resistivity as a function of temperature showed activated transport as a function of temperature at all compositions between 9 and 300 kelvins. Core level photoemission spectroscopy showed weak hybridization of Ce 4f orbitals with the valence band for $x<11$ and strong hybridization at high cerium concentration. Valence band photoemission spectroscopy shows electronic correlation effects.

14. SUBJECT TERMS

fulleride, cerium, resistivity, photoemission spectroscopy, XPS, UPS, co-evaporation.

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FINAL REPORT

to the

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH

for a program in

SUPERCONDUCTIVITY OF FULLERENES AND SCANNING TUNNELING MICROSCOPY OF NOVEL SUPERCONDUCTORS

for the period 7/1/92-6/30/95

under

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Final Report
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M. R. Beasley and T. H. Geballe
Supported Student: S. Arnason

In the final year of this study we have used the hardware that we have developed and the experience in growing fullerene compounds by co-evaporation that we have acquired to perform an in-depth study of cerium fulleride compounds.

We have used the photoemission spectroscopy capabilities of the Molecular Beam Synthesis facility (MBS) with the ultra-high vacuum cryogenic and transport measurement fixturing that we have developed under this contract to correlate the electronic structure of cerium fullerides with their transport properties as a function of composition. The range of compositions studied varied between Ce0.5 C60 and Ce12.8C60.

Using the room temperature resistivity as a function of composition, we were able to determine that there is a cerium fulleride compound that forms at a composition of Ce5C60. Increasing the cerium concentration beyond this range, we were able to generate samples with resistivities approaching the metallic limit, but which when studied as a function of temperature always showed insulating behavior. This is indicative of the effects of disorder produced by the co-evaporative growth process in fullerene compounds. By studying the cerium 3d core level electron photoemissions spectra (XPS) we were able to examine the valence and hybridization of the cerium ions in these compounds. At low cerium concentration there is weak hybridization of the unfilled inner shell f electrons, but at cerium concentrations greater that Ce11C60 there is a marked change in the electronic structure. This increase in f-electron hybridization correlates with the appearance of a plasmon satellite near the carbon 1s core level peak in XPS. The existence of this satellite suggests the existence of collective electronic excitations on the fullerene molecules in this compound. No similar phenomena have yet been reported in the literature.

This work was presented at the American Physical Society March Meeting in San Jose. A more detailed version is being prepared for publication and represents the bulk of Arnason's dissertation.

The student supported under this grant is receiving satisfactory grades.